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Use of Solar Energy for Energy Savings in Dairy Processing Industry

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Abstract

Due to increase in population, there is a large demand for electricity in India and it is difficult to supply this required energy from conventional energy resources because of environmental constraints and scarcity of resources. The best alternative is to generate electricity from renewable energy sources such as solar and wind which are environmentally friendly and freely available in nature. Indian government is providing subsidies, in order to encourage the electricity generation from solar. According to the Ministry of new and renewable energy Government of India, Dairy industry is suggested as one of the most suitable industrial areas for the commercialization of solar energy. Major developments in this field will however take a long time to reach a commercially feasible level. Dairies have considerable advantages in that as they are high energy users with a relatively constant demand for electricity throughout the year. The use of solar energy which is more adaptable to the dairy can be effectively and directly utilized as alternative and supplement to the existing energy supply. In this paper study is carried out to find the opportunities for electrical energy generation from solar in dairy processing unit. [1]

Keywords: Solar, Rooftop photovoltaic, PV system Design.

I. Introduction

The depletion in conventional resources on a worldwide basis has necessitated urgent research for alternative energy sources to meet up the present load demands. Solar energy is inexhaustible and environmental-friendly potential resource among all renewable energy resources. But in present scenario, there is a need of continuous supply of energy, which cannot be fulfilled alone by the grid. Therefore, in order to meet the load demand and increase the power generation, solar and other conventional conversion units are now being implemented as a Grid connected energy systems. Solar power is an emerging technology that has the potential to reshape the way we think about energy and where it comes from. By harnessing the free energy given off by the sun it is possible to lower or eliminate the cost of powering daily electrical needs. [2]

Dairy is a sector where a majority of energy requirements can be fulfilled by renewable energy. Dairies have considerable advantages in that as they are high energy users with a relatively, constant demand for electricity and heat throughout the year. Dairy owners across geographies are unaware that their electricity requirements can be tackled by solar technologies. Unfortunately, only a few respondents say that they are using renewable energy to fulfill their energy requirements. Smart dairy workers are cutting their electrical energy costs by milking the free energy in their dairy sheds and it is good for environment too. [3]

II. Problem Statement

Energy is the critical input for all the production activity in dairy. As the demand for electricity increasing day by day, due to increase in population and lifestyle of people, there exists imbalance between the production and demand. Generation of energy by conventional energy sources may decrease in future years due to the non- availability of these sources and environmental constraints. [4]

III. Objective

The main objective of this work is to lessen the dependence on fossil fuel based electricity generation and encourage environment friendly solar electricity. It also creates enabling environment for supply of solar power from rooftop to grid and also it encourages replacement of conventional energy sources wherever possible. [5]

IV. Literature Review

1. **Prof. R. H. Yadav [6]** presented a paper which gives an introduction about renewable energy sources, their needs, highlighting the advantages of using the renewable sources over conventional energy sources. Renewable energy offers a good opportunity for dairies to reduce their carbon footprint and at the same time reducing energy costs. There are a number of renewable energy technologies with potential for use in dairies. He explains the scope for renewable energy in dairy. Electricity generation using solar PV cell, design of proposed system, components of solar PV system, principle of electricity generation through solar and the benefits of using solar energy.
2. **Justin Mason [7]** presented a Senior Project to the Faculty of the Dairy Science California Polytechnic State University, San Luis Obispo, regarding the feasibility of adding solar panels to offset energy usage on a dairy farm. The project involved the collection of data. Evaluation of investment, calculation of payback period and internal rate of return. Also. Dairies energy usage was evaluated and a the most beneficial design for the system was determined. The study consists of designing a system, materials and the methods used and the results obtained.
3. **Midhun Baby Neerkuzhi, Jenson Joseph E [8]** presented a paper in International Journal of Scientific and Research Publications stated that According to the Ministry of new and renewable energy, Government of India. Dairy industry suggested as one of the most suitable industrial areas for the commercialization of solar energy. This paper aims to find out the opportunities of solar energy in a dairy processing plant. This study is very important in India, because India is an energy deficient country. Moreover solar technologies are environmentally friendly. This study was conducted at a dairy plant which is located at Kerala state in India. The plant has a capacity of processing about 100000 liters of milk per day. The first step is to identify the energy needs in the dairy plant. Then it preceded with the study of the existing energy sources. This paper suggests that the solar technology is suitable in place of each energy source. At last they conducted a technical economic feasibility study. Also conducted an ecological benefit study. The details consisted of the collection of the data. Work done that includes the design of solar voltaic panels for electrical energy applications, calculation of the payback period. Economic feasibility study and ecological benefit. It predicts the results that solar technology is the best renewable option for dairy industry.

V. Renewable Energy Option for SHIMUL Dairy Industry

A questionnaire was drafted and finalized. Since the survey was conducted to understand the dairy industry from the SHIMUL industry's perspective, almost all the question were directed to get a dairy owners' understanding for the SHIMUL industry.

- **Data collection**: Once the questionnaire was finalized, the diary owners were approached for a Collection of data.
- **Data analysis**: The collected data are used to analyze the daily load variation and total demand in SHIMUL etc.
- **Solar radiation measurements:** Lux-meter is used to determine the solar radiation available at the site. Estimation of solar energy available in the site using mathematical Preparation of Report to SHIMUL for solar energy implementation.[9][10]

➢ Electricity generation using solar PV cell:

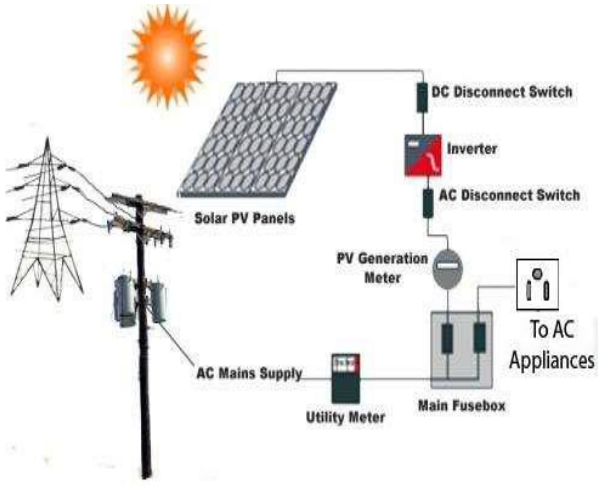

Fig 1: Schematic diagram of proposed system

➢ Components of Solar PV system

- **Solar PV Panels:** Converts sunlight into DC electricity.
- **Solar Charge Controller:** Regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life. **Inverter:** Converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line. **Battery:** Stores energy for supplying to electrical appliances when there is a demand.
- **Load:** It is electrical appliances that connected to solar PV system such as lights, computer, fans etc.[11][12]

➢ Solar PV panel design

Here we are assuming that Inverter efficiency is about 70%.

Sunlight available in a day = 8 hours/day (equivalent of peak radiation)

Utilization of electricity per month in the production plant = 2lakh units of electricity approximately.

PV Panel Power rating = 1KWp

A solar PV system design can be done in five steps:

Here we are assuming inverter efficiency of 70%.

In operating conditions, the actual output power of a PV module is less than the theoretical conditions. Thus, a factor called 'Operating Factor' is used to estimate the actual output from a PV Module. The

operating factor can vary between 0.60 and 0.90 in normal operating conditions depending upon temperature, dust on module etc. An operating factor of 0.75 is considered in these calculations assuming the worst condition may occur.[13][14][15]

- **Load calculation**

Total Energy consumption=6600KWH/day If a day is split into three time zones (9am to5pm, 5pm to 1am and lam to 9am) then energy consumption per zone=6600/3=2200KWH/Zone. Considering the solar power availability between 9 am and 5pm, the average power demand =2200/8=275KW.

- **Estimation of Number of PV Panels**

Actual power output of a PV Panel = Peak power rating x operating factor

= 1*0.75 = 0.75 KW

The power available for end use = Actual power output of a panel * Inverter Efficiency = .75X0.7 = 0.525 KW

Energy produced by one 1KWp panel in a day = Actual power output x 8 hours/day = 0.525x8= 4.2 KWH

Number of PV Panels required = Total watt-hour rating (daily)/Daily Energy produced by panel =2200/4.2=524 panels

But, the actual number of PV Panels can be installed in 2800 m²=total area available/area of single panel=2800/12= 233 panels

- **Surveying the Site**

Area required to install the system= Number of panels (1kw) x12m^2= 524x12 = 6288 m² but available roof top area for the installation of PV system = 2800 m²

No. of PV panels that can be installed in this area is=2800/12 = 233

No. of units that can be obtained from 233 panels=233*4.2KWh/panel=980KWh So, out of 2200units of demand, the solar power will meet 980 units hence remaining 1220units have to be borrowed from the grid.

- **Cost analysis of the system**

Cost estimation of a solar PV System for Dairy plant is done here. After finding out the required number and capacity of various system components like panels, inverter, estimated costs is calculated by adding the cost of all components. But some margin should be taken for other cost like wiring, supporting infrastructure for panel etc.[16][17]

- **For mono crystalline**

Equipment cost per KW = Cost of solar panels (A) + Cost of Inverter (B) + installation cost =Rs 0.75lakh/KW

Total Cost of a system = 233*Rs0.75lakh/KW = Rs.1.75Crores Operating and maintenance cost of the system =Rs.3025/KW/year=3025X233=Rs. 7.05lakhs

(Source: Electric Power Research Institute, "Engineering and Economic Evaluation of Central-Station Solar Photovoltaic Power Plants)

Total investment=Rs.1.82crores

Energy output in a day=233x4.2KWH = 980units

Total units consumed in dairy in one day = 2,200 units

A) Energy contribution by solar panel = 980 units

B) Energy contribution by MESCOM = 2200-980 = 1220units

Annual solar energy contribution = 980 x 30 x 12 = 3, 52,800 units

Cost savings@6Rs per unit/annum = 3, 52,800 x6 = Rs.21, 16,800

Payback period = total investment / savings = 1, 82, 00,000/21, 16,800=8.6years

- **For polycrystalline**

Equipment cost per KW= Cost of solar panels (A) + Cost of Inverter (B) + installation cost =Rs 0.65lakh/KW

Total Cost of a system 233* Rs 0.65lakh/KW = Rs.1.5Crores

Operating and maintenance cost of the system =Rs. 8.05Lakhs

(Source: Electric Power Research Institute, "Engineering and Economic Evaluation of Central-Station Solar Photovoltaic Power Plants)

Total investment = Rs 1.6crores

Energy output in a day=233x3.2KWH = 746 units

Total units consumed in dairy in one day = 2,200 units

A) Energy contribution by solar panel =746 units

B) Energy contribution by MESCOM = 2200-746 = 1454units

Annual solar energy contribution = 746 x 30 x 12 = 2, 68,560 units

Cost savings @6Rs per unit/annum =

2, 68,560 x6 = Rs.16, 11,360

Payback period = total investment / savings=1, 60, 00,000/16, 11,360=10years

- **For thin film**

Equipment cost per KW = Cost of solar panels (A) + Cost of Inverter (B) + installation cost =Rs 0.4lakh/KW

Total Cost of a system = 233* Rs 0.4lakh/KW = Rs. 0.9Crores

Operating and maintenance cost of the system =Rs. 9.05Lakhs

(Source: Electric Power Research Institute, "Engineering and Economic Evaluation of Central-Station Solar Photovoltaic Power Plants)

Total investment = Rs 1crore

Energy output in a day=233x1.8 KWH = 419 units

Total units consumed in dairy in one day = 2,200 units

A) Energy contribution by solar panel = 419 units

B) Energy contribution by MESCOM = 2200-419 = 1780 units

Annual solar energy contribution = 419 x 30 x 12 = 1, 50,840 units

Cost savings @6Rs per unit/annum 1, 50,840x6 = Rs. 9, 05,040

Payback period = total investment / savings = 1, 00, 00,000/ 9, 05,040 = 13 years

Table 1: Summery of the result

Types of PV Module	Efficiency in %	Capital investment in Rs	Annual saving in units(KWh)	Cost savings @Rs6/unit/annum	Payback period in years
Monocrystalline	21	1.82crores	3,52,800units	Rs 21,16,800	8.6
crystalline	16	1.6crores	2,68,560units	Rs16,11,360	10
Thin film	12	1crore	1,50,840units	Rs9,05,040	13

VI. Result and Discussion

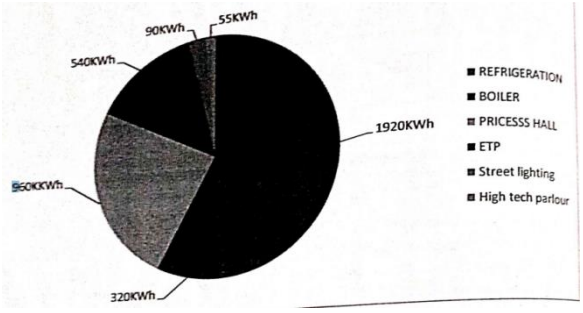

Fig 2: Unit wise Daily Energy Consumption Profile in KWh

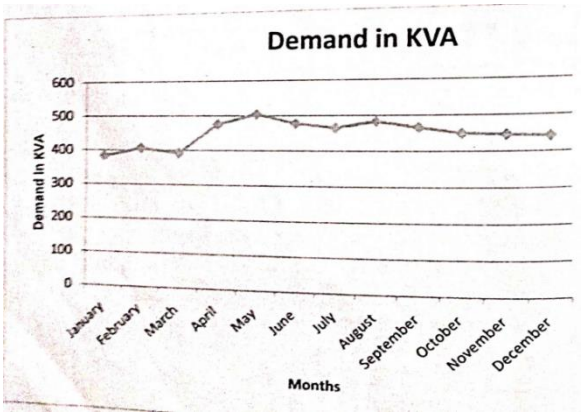

Fig 3: Electricity Demand Curve

With the cost of solar PV systems decreasing, alongside rising fossil fuel and electricity prices, implementing a rooftop solar PV system is becoming an attractive option, even in heavily urbanized areas. This study has predicted increased energy demand in SHIMUL's future, and rooftop solar PV is one option, among many alternative energy solutions, that can meet that demand in a sustainable manner.

VII. Conclusion

The objective of this study is to explore the scope of renewable energy technologies in dairies to reduce dependence on conventional energy sources. This study will help dairy processing facility managers to understand the importance of renewable energy and uncover opportunities to significantly reduce the energy consumption.

With the cost of solar PV systems decreasing, alongside rising fossil fuel and electricity prices, implementing a rooftop solar PV system is becoming an attractive option, even in heavily urbanized areas. This study has predicted increased energy demand in SHIMUL's diary and rooftop solar PV is one option, among many alternative

energy solutions, that can meet the demand in a sustainable manner. In this study cost analysis is also done for different PV module along with its payback period and it is given in table 1.

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